

Predictability Assessment and Improving Ensemble Forecasts

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PROJECT GOALS AND OBJECTIVES

The PI continues to examine atmospheric predictability with the goal of improving ensemble forecasts at ranges of 12 hours to 10 days. The research is addressing several issues, including:

1. Documentation of analysis uncertainty from mesoscale and global analyses.
2. Calibration of ensemble forecast system (EFS) output by artificial neural networks.
3. Design of optimal EFS's, with an emphasis on precipitation forecasts.
4. Design of stochastic physics parameterizations that improve under-dispersion in EFS's.

Most progress during the past year involved topics 1 and 2, so descriptions of new results will focus there. The PI also served as Co-Chief Scientist to Dr. Simon Chang for ONR initiative on Predictability in the Atmosphere and Ocean, and presumably will continue to serve as Co-Chief Scientist on the initiative until its termination in 2003.

DOCUMENTATION OF ANALYSIS UNCERTAINTY

As noted in last year's report, we are estimating lower bounds for the statistics of analysis errors E_o from differences between different analysis-forecast systems. This approach defines a "component" of the analysis uncertainty. Although this methodology is not as theoretically appealing as statistics from ensemble data assimilation or observing system simulation experiments, it is currently tractable, very economical, and useful guidance can be quickly obtained.

PI continued collaboration with DRI participants Errico, Baumhefner and Tribbia (NCAR) to document analysis uncertainty in global analyses. Analyses from ECMWF and NCEP are being compared and similar statistics are being computed for the global difference fields, and now includes moisture and decomposition of the wind fields. This work is the natural complement to the LAM documentation reported last year. A 2D spectrum is shown in Fig. 1 for 700 mb specific humidity, a field for which difference statistics indicate small confidence in our analyses.

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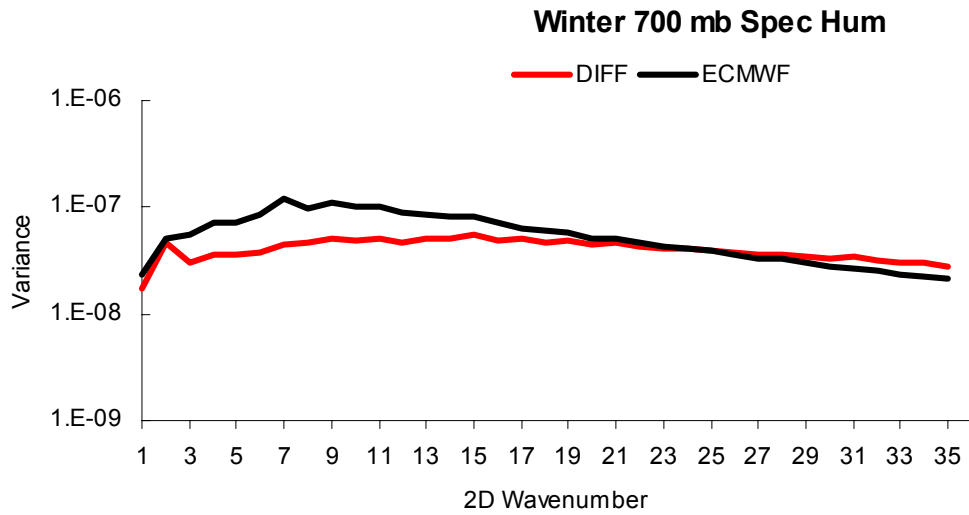


Fig. 1. Two-dimensional variance spectra for 700 mb specific humidity for the 1992/93 boreal winter. Spectrum for differences between ECMWF-NCEP global analyses (red) and for ECMWF analyses (black). The difference variance equals or exceeds the analysis variance beyond wavenumber 24.

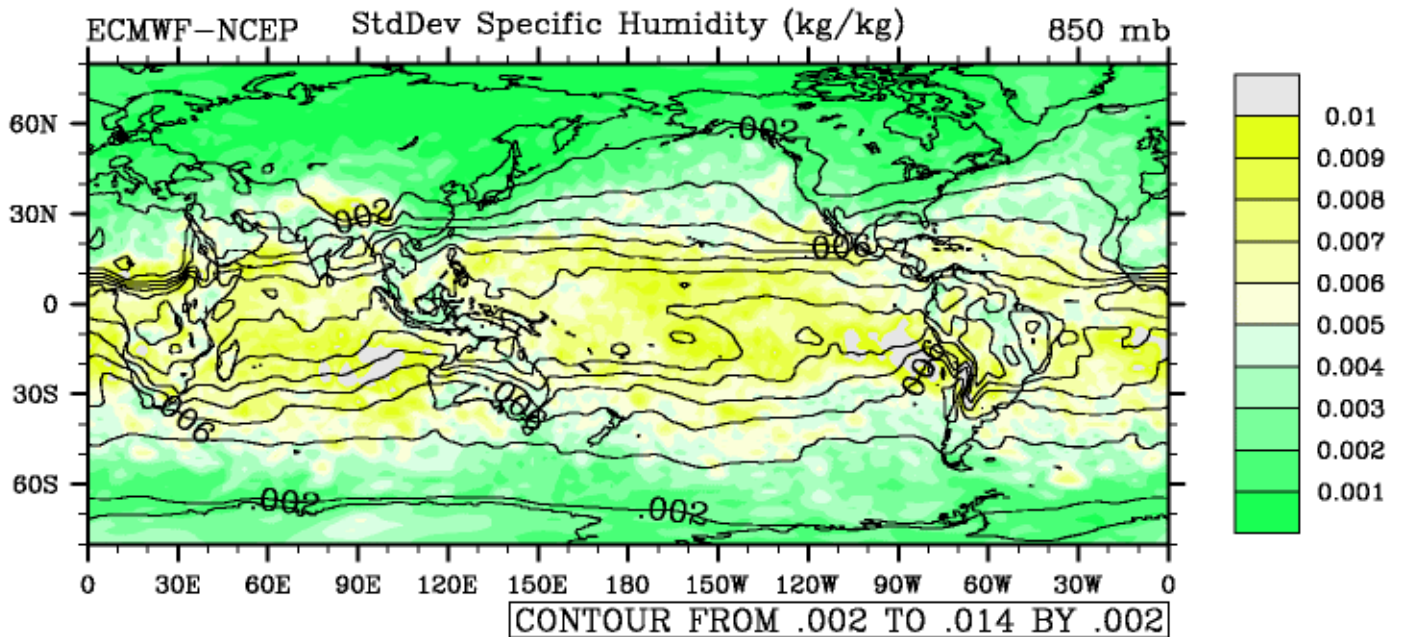


Fig. 2. Distribution of the maximum value (color fill) of 850 mb specific humidity differences for the 1992/93 boreal winter and the seasonal-average ECMWF specific humidity (contours every 0.02). Note that the maximum difference can exceed 0.01 over the tropical oceans.

The variance for the difference between analyses is as large as the variance for ECMWF fields for wavenumbers higher than 24, which indicates *global analyses of moisture contain little useful information for wavelengths shorter than 15° latitude (~1,600 km)*. Moreover, those scales for which the analysis variance (wavenumbers 3-15) clearly exceeds the difference variance only run a factor of 2-3 larger, indicative of *overall low confidence for analyses of moisture*. Fig. 2 gives the distribution of the bias corrected maximum values of the differences. Large values characterize the tropical oceans. *In all regions, daily differences can approach the time-mean signal*. The PI has completed 14 pages of a first draft for a manuscript that will report these results.

NEURAL NETWORK POST-PROCESSING OF ENSEMBLE FORECAST PRODUCTS

Because forecast fields produced by any NWP model always contain errors due to model deficiencies (e.g. lack of resolution, inadequate parameterizations, truncation error, etc), raw model output is often statistically post-processed to mitigate their impact. Post-processing also provides a way to relate model output fields to weather elements not explicitly forecast by the NWP model (e.g. visibility, probability of thunder).

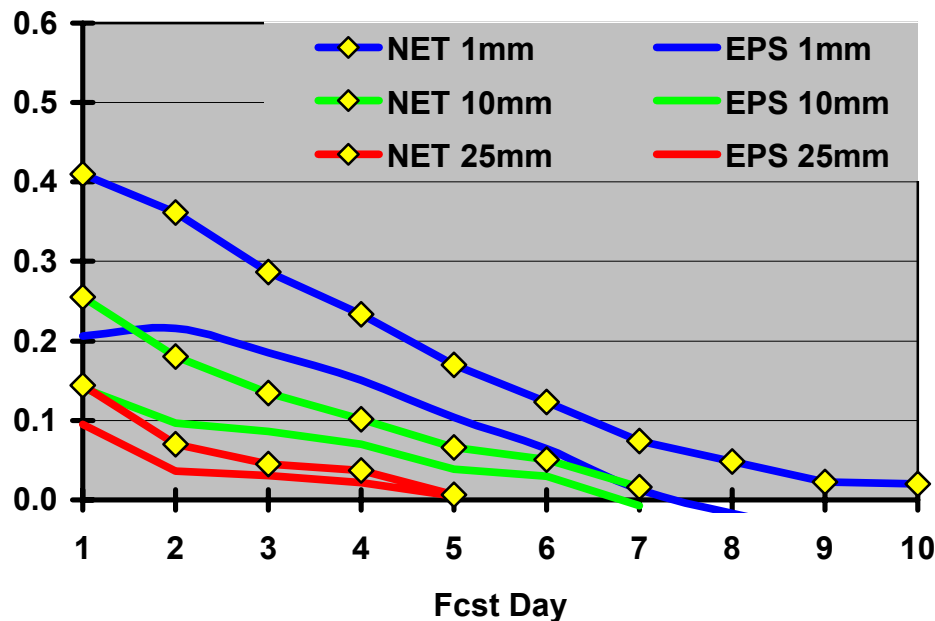


Fig. 3. Brier Skill Score for EPS forecasts (solid lines) and ANN calibrated EPS forecasts (lines with diamonds) at the indicated thresholds of 24 h accumulated precipitation for the warm season over the conterminous U.S. Average of verification at rain gauges for three regions: coastal Pacific Northwest, Central Oklahoma and Washington D.C.

Calibration of ensemble output with artificial neural networks (ANNs) was expanded to include the ECMWF Ensemble Prediction System (EPS) over the past year. ANNs are computer algorithms that are particularly suited for nonlinear optimization. A back-propagation ANN was used to process to QPF output for the period 1 January 1997 to 31 July 2002. The *ANN calibration markedly improves the unprocessed ensemble for thresholds up to 10 mm per day. Relative improvement tends to be larger early in the forecast, or the projection for which the model tends to be most skillful. The improvement comes from an improved reliability, the forecast probability matching the observed frequency of occurrence. The resolution term of a Brier Score decomposition, which is related to the ability to pick*

up day-to-day cases in event occurrence, did not improve, however. Over the final year of the contract, collaborator R. Buizza of ECMWF and the PI will be exploring the utility of including model predictors besides precipitation. We hypothesize the inclusion of such predictors will lead to minor improvements in resolution or forecast specificity. We also plan to test how post-processing affects the design of optimal ensemble forecast systems, the tradeoff between number of ensemble members and model resolution (Mullen and Buizza 2002). These results will be reported in papers that are still more than one year from submission.

PUBLICATIONS (IN PRESS, SUBMITTED OR IN PREPARATION)

Mullen, S. L., and R. Buizza, 2002: The impact of horizontal resolution and ensemble size on probabilistic precipitation forecasts by the ECMWF ensemble prediction system. *Wea. Forecasting*, **17**, 173-191. (Reported last year as in press.)

Bright, D. A. and **S. L. Mullen**, 2002: The sensitivity of the numerical simulation of the Southwest monsoon boundary layer to the choice of PBL turbulence parameterization in MM5. *Wea. Forecasting*, **17**, October Issue. (Reported last year as in press.)

Mullen, S. L., M. M. Poulton, H. E. Brooks, T. M. Hamill, 2002: Calibration of ensemble precipitation forecasts by an artificial neural network. *Wea. Forecasting*, to be submitted late 2002 calendar year...good health continuing! (Also reported last year as to be submitted in early 2001 calendar year, but it was not despite my best intentions.)

In-House/Out-of-House Ratios

All research is 100% out-of-house.